TECHNICAL PROGRESS AND INDUSTRIAL DEVELOPMENT IN A DEVELOPING ECONOMY

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THESIS

TECHNICAL PROGRESS AND INDUSTRIAL

DEVELOPMENT IN A DEVELOPING ECONOMY

by

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TECHNICAL PROGRESS AND INDUSTRIAL DEVELOPMENT IN A DEVELOPING ECONOMY

by

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Major, Indonesian Navy

Submitted in partial fulfillment of the
requirements for the degree of

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December 1974

ABSTRACT

This study of development theory contains an analysis of technical progress and industrial labor force absorption in a model of a closed economy. The production process for the system is described by a neoclassical production function with factor-augmenting technical change. This study is directed to the study of economic development in low income country.

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I. INTRODUCTION

A. BACKGROUND

The industrial and agricultural sectors are very important in the study of economic growth in a developing economy. The structural change or the shift from rural-agricultural to urban-industrial activity has not only been empirically verified as accompanying growth, but it has been postulated as a major factor explaining economic development. The major influences affecting industrial patterns are not the determinants of demand but rather those of supply.[1]

The sources of growth methodology initated by Solow's paper,[2] relies heavily on the neoclassical concept of an aggregate production function and highlights supply conditions. It examines the contribution of current factor input expansion and technical change to current output growth.

One of the important problems of economic development in low income countries, especially in overpopulation countries, is the reallocation of the labor surplus from one sector to other sectors to get higher productivity. The industrial development can be explained by the labor force absorption in these latter sectors.

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[1]H.B. Chenery, Patterns of Industrial Growth, American Economic Review 50, September 1960, pp. 624-54.

[2]R.M. Solow, Technical Change and The Aggregate Production Function, Review of Economics and Statistics 39, August 1957, pp. 312-20.

B. THE BASIC MODEL

The approach of this study is the industrial and agricultural sector model in a closed economy. The production process for the system is described by a continuous, twice differentiable single-valued function. This function represents neoclassical production function with factor augmenting technical change.

C. OBJECTIVE

The purpose of this study is to explain the relationships between the important characteristics of economic development and the determinant factors.

The important characteristics are:

1. The rate of technical progress.
2. The direction of technical progress.
3. The labor force absorption in the industrial sector.

And the final part of this thesis describes the interrelationships between industrial sector and agricultural sector.

NOTATIONS

Y_i = Output or the total product of good in i^{th} sector

$B(t)$ = factor augmentation of capital

$A(t)$ = factor augmentation of labor

$\tau_i(t)$ = the intensity of technical progress in i^{th} sector

$\alpha_i(t)$ = output elastisity of capital in i^{th} sector

P_i = the total product of capital in i^{th} sector

k_i = capital-labor ratio

y_i = $f^i(k)$

ω_i = wage-rental-ratio in i^{th} sector

$$= \frac{\text{wage per unit of labor}}{\text{rent per unit of capital}}$$

$F_1^i = F_{BK}^i = \frac{\partial F^i}{\partial BK}$

$F_2^i = F_{AL}^i = \frac{\partial F^i}{\partial AL}$

$F_{12}^i = \frac{\partial^2 F}{\partial BK \partial AL}$

$D_i(t)$ = the direction of technical progress in i^{th} sector

$\sigma_i(t) = \frac{F_1 F_2}{F F_{12}}$ = the elasticity of factor substitution

$p(t) = \frac{F_{1t}}{F_1}$ = time rate of increase of marginal product of capital

$q(t) = \frac{F_{2t}}{F_2}$ = time rate of increase of marginal product of labor

II. TECHNICAL PROGRESS IN INDUSTRIAL AND AGRICULTURAL SECTOR

A. THE MODEL

We consider a basic model of a growing economy, a closed economy in which there exists two productive sectors, one is the agricultural sector and the other is the industrial sector. The output of the agricultural sector are consumption goods. The industrial output may be consumed or invested or both. The output is assumed to be composed of homogeneous quantities and to be produced by two homogeneous factors of production; labor and capital. Each sector is analogous to a large firm or industry having a production function and exhibiting optimal behavior. Such behavior implies cost minimization with respect to inputs and revenue maximization with respect to output. The production function for each sector is [3]

$$Y_i(t) = F^i(B(t)K_i(t),\ A(t)L_i(t)) \qquad 1\text{-}1$$

$$i = 1,\ 2$$

Sector 1 is industrial sector, sector 2 is agricultural sector. The production in each sector is subject to constant returns to scale, and diminishing marginal rates of substitution are assumed to prevail. $Y_i(t)$ is the quantity of the i^{th} good currently produced. $K_i(t)$ are the amount of Capital and Labor currently employed in the i^{th} sector. K(t) and L(t) are

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[3]Edwin Burmeister and A. Rodney Dobell, Mathematical Theories of Economics Growth. The Macmillan Co., 1971, pp. 218-224.

positive. Also $B(t)$ and $A(t)$ are positive and they are independent of the capital-labor ratio. $B(t)K_i(t)$ is referred to as effective capital and $A(t)L_i(t)$ is referred to as effective labor. It is assumed that $B(t)$ and $A(t)$ grow at exogenously given rates, b and a, respectively.

$$B(t) = B(0)\ e^{bt} \qquad 1\text{-}2$$

$$A(t) = A(0)\ e^{at} \qquad 1\text{-}3$$

B. THE NATURE OF TECHNICAL PROGRESS

The two characteristics of technical progress that are important in the analysis of a developing economy are:

1. The current rate of technical progress or intensity of technical progress in ith sector, $\tau_i(t)$, which measures the output raising effect of technical change, holding the input of capital and labor constant.
2. The factor-saving bias or the direction of progress in the ith sector, $D_i(t)$, which traces the output-rising effect to the specific input.

The production function for each sector is

$$Y_i = F^i \left[B(t)K_i(t),\ A(t)L_i(t)\right] \qquad 1\text{-}4$$

$$\dot{Y}_i = \frac{\partial Y_i}{\partial B}\frac{dB}{dt} + \frac{\partial Y_i}{\partial K_i}\frac{dK_i}{dt} + \frac{\partial Y_i}{\partial A}\frac{dA}{dt} + \frac{\partial Y_i}{\partial L_i}\frac{dL_i}{dt}$$

$$\frac{\dot{Y}_i}{Y_i} = \frac{B}{Y_i}\frac{\partial Y_i}{\partial B}\frac{\dot{B}}{B} + \frac{K_i}{Y_i}\frac{\partial Y_i}{\partial K_i}\frac{\dot{K}_i}{K_i} + \frac{A}{Y_i}\frac{\partial Y_i}{\partial A}\frac{\dot{A}}{A} + \frac{L_i}{Y_i}\frac{\partial Y}{\partial L}\frac{\dot{L}_i}{L_i} \qquad 2\text{-}5$$

τ_i is defined as $\frac{\dot{Y}_i}{Y_i}$ for fixed inputs

$$\tau_i = \frac{\partial Y_i}{\partial B}\frac{B}{Y_i}\frac{\dot{B}}{B} + \frac{\partial Y_i}{\partial A}\frac{A}{Y_i}\frac{\dot{A}}{A} \qquad 2\text{-}6$$

$$\frac{\dot{A}}{A} = a, \quad \frac{\dot{B}}{B} = b$$

$$\frac{\partial Y_i}{\partial B}\frac{B}{Y_i} = \frac{\frac{\partial Y_i}{Y_i}}{\frac{\partial (BK)}{BK}} = \alpha_i \qquad 2\text{-}7$$

where α_i = output elasticity of capital

The production function is subject to constant returns to scale, thus the function coefficient is identically one or the output elasticity of labor = $1-\alpha_i = \frac{\partial Y_i}{\partial A}\frac{A}{Y_i}$ Denote the total product of capital in the i^{th} sector by P_i, then

$$P_i = BK_i \frac{\partial Y_i}{\partial (BK)_i} \qquad 2\text{-}8$$

= capital x the rate of return on capital.

(BK is effective capital)

$$\alpha_i = \frac{P_i}{Y_i} \qquad 2\text{-}9$$

= relative share of capital

If the wage of labor is W_i

$$W_i(t) = (AL_i)\left(\frac{\partial Y_i}{\partial AL_i}\right) = (1-\alpha_i(t))\ Y_i \qquad 2\text{-}10$$

$(1-\alpha_i(t))$ is the relative share of labor.

Equation 2-6 becomes

$$\tau_i(t) = b\alpha_i(t) + a(1-\alpha_i(t)) \qquad 2\text{-}11$$

For the industrial sector,

$$\tau_1(t) = b\alpha_1(t) + a(1-\alpha_1(t)) \qquad 2\text{-}12$$

For the agricultural sector,

$$\tau_2(t) = b\alpha_2(t) + a(1-\alpha_2(t)) \qquad 2\text{-}13$$

The difference of technical progress between industrial sector and agricultural sector is,

$$\tau_1(t)-\tau_2(t) = (b-a)(\alpha_1(t)-\alpha_2(t)) \qquad 2\text{-}14$$

$(\tau_1(t)-\tau_2(t))$ is less or greater than zero, depending on two factors, (b-a) and $(\alpha_1(t)-\alpha_2(t))$

Proposition

If the production function is subject to constant returns to scale, and $k_1 > k_2$, then $(\alpha_1(t)-\alpha_2(t)) > 0$.

Proof:

$$y_i = f^i(k_i) \qquad 2\text{-}15$$

$$y_i = \frac{Y_i}{AL_i} = F^i\left(\frac{BK_i}{AL_i}, 1\right) \qquad 2\text{-}16$$

$$Y_i = AL_i y_i$$

$$F_1^i = \frac{\partial}{\partial BK}\left[AL\ f^i(k)\right] = AL\left[f'(k)\ \frac{\partial k}{\partial (BK)}\right]$$

$$= AL\left[f'(k)\right]\ \frac{1}{AL} = f'(k) \qquad 2\text{-}17$$

$$F_2^i = \frac{\partial}{\partial AL}\left[AL\ f(k)\right] = f(k) + AL\left[f'(k)\frac{\partial k}{\partial AL}\right]$$

$$= f(k) + L\left[f'(k)\left(-\frac{K}{L^2}\right)\right] = f(k)-kf'(k) \qquad 2\text{-}18$$

$$\text{Wage-rental-ratio} = \frac{\text{Wage per unit of labor}}{\text{rent per unit of capital}}$$

$$= \frac{F_2^i}{F_1^i}$$

$$= \omega_i \qquad 2\text{-}19$$

$$\text{for sector i, } \omega_i = \frac{F_2^i}{F_1^i} = \frac{f_i(k_i)}{f_2^1(k_i)} - k_i \qquad 2\text{-}20$$

$$f_i(k_i) = \frac{Y_i}{AL_i}$$

$$f_2'(k_i) = F_1^i = \frac{\partial Y}{\partial BK} = \frac{P}{BK} = \frac{\alpha Y}{BK}$$

$$\omega_i = \frac{k_i}{\alpha_i} - k_i = \frac{k_i}{\alpha_i}(1-\alpha_i) \qquad 2\text{-}21$$

We assume $\omega_1 = \omega_2 = \omega$ (in equilibrium)

$$\frac{k_1}{\alpha_1}(1-\alpha_1) = \frac{k_2}{\alpha_2}(1-\alpha_2) \qquad 2\text{-}22$$

$$\frac{k_1}{k_2} = \frac{\alpha_1}{\alpha_2}\frac{(1-\alpha_2)}{(1-\alpha_1)} \qquad 2\text{-}23$$

$$k_1 > 0, \alpha_1(1-\alpha_2) > 0$$

$$\frac{(k_1-k_2)}{(\alpha_1-\alpha_2)} \quad \frac{k_1}{\alpha_1(1-\alpha_2)} \qquad 2\text{-}24$$

if $(k_1-k_2) > 0$ then $\alpha_1(t)-\alpha_2(t) > 0$

Thus when a > b and the output elasticity of capital is greater

in industry, then the rate of technical progress in the agricultural sector exceeds that in the industrial sector.

The second characteristic of technical progress is the factor saving bias, $D_2(t)$. $D_2(t)$ is defined to be the proportionate rate of change in the marginal rate of factor substitution,

$$D_i(t) = p_i(t) - q_i(t) \qquad 2\text{-}25$$

$$= \frac{F^i_{1t}}{F_1} - \frac{F^i_{2t}}{F_2}$$

$$D_i(t) = \frac{\partial F^i_1}{\partial t}\frac{1}{F^i_1} - \frac{\partial F^i_2}{\partial t}\frac{1}{F_2} \qquad 2\text{-}26$$

With the production function,

$$Y_i(t) = F^i\left[B(t)K_i(t),\ A(t)L_i(t)\right] \qquad 2\text{-}27$$

$$\alpha_i(t) = \frac{\left(\frac{\partial F^i}{\partial (BK)}\right)BK}{F^i}$$

$$1-\alpha_i(t) = \frac{\left(\frac{\partial F^i}{\partial (AL_i)}\right)AL}{F^i}$$

and the elasticity of substitution between capital and labor is

$$\sigma_i(t) = \frac{F^i_1 F^i_2}{F^i F^i_{12}} \qquad 2\text{-}28$$

then $p(t)$ and $q(t)$ can be derived and we obtain (in Appendix),

$$p_i(t) = b - \frac{1-\alpha_i(t)}{\sigma_i(t)}(b-a) \qquad 2\text{-}29$$

$$q_i(t) = a + \frac{\alpha_i(t)}{\sigma_i(t)} (b-a) \qquad 2\text{-}30$$

$$D_i(t) = \frac{(a-b)\left[1-\sigma_i(t)\right]}{\sigma_i(t)} \qquad 2\text{-}31$$

Thus, the nature of the bias in the i^{th} sector depends on the difference between the growth rates of factor augmentation and on the magnitude of the current elasticity of factor substitution.

Case a The technical change for labor augmenting ($a > b$) will be labor saving ($D_i(t) > 0$) or capital saving ($D_i(t) < 0$) depending on whether $\sigma_i(t)$ is less or greater than unity, respectively.

Case b The technical change for capital augmenting ($b > a$), then the technical change will be capital saving or labor saving depending on whether $\sigma_i(t)$ is less or greater than unity.

Case c For $a=b$, implies that technical change is neutral regardless of the value of $\sigma_i(t)$.

There is considerable empirical evidence that technical change is nonneutral.[4]

It is frequently the case that in low income economies, agricultural technologies are endogenously developed, and with their labor-using bias they tend to reflect the relative

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[4]Allen C. Kelly, Jeffrey G. Williamson, and Russell J. Cheetham. Dualistic Economic Development, Theory and Development, The University of Chicago Press, 1972, pp. 32.

abundance of labor. The production process in the industrial sector is considered to be more capital intensive than that in agricultural sector. There are restrictions on the elasticity of substitution in the industrial and agricultural sectors.[5,6] In the industrial sector the current elasticity of substitution of effective labor for effective capital is

$$0 < {}_1(t) < 1 \qquad 2\text{-}32$$

and in agricultural sector

$$1 \leq \sigma_2(t) < \infty \qquad 2\text{-}33$$

where

$$\sigma_i(t) = \frac{F_1^i \, F_2^i}{F^i \, F_{12}^i} \qquad 2\text{-}34$$

$$F_1^i = \frac{\partial F^i}{\partial [AK_i]}, \quad F_2^i = \frac{\partial F^i}{\partial [AL_i]}, \quad F_{12}^i = \frac{\partial F_1^i}{\partial [AL_i]}$$

Griliches's research on American agriculture suggests high substitution elasticities, at least with $\sigma_2(t) > 1$ and in general none of the evidence drawn from developing economies conflicts with the results of Griliches.[7] Ferguson and Moroney supported the hypothesis that $0 < \sigma_1(t) < 1$.

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[5]Allen C. Kelly, Jeffrey G. Williamson, and Russell J. Cheetham. Dualistic Economic Development, Theory and Development, The University of Chicago Press, 1972, pp. 25.

[6]Ferguson C.E., and Moroney J.R., The Sources of Change in Labor's Relative Share, Southern Economic Journal 35, April 1969, pp 308-322.

[7]Ibid.

The Ferguson and Moroney result has been supported by Williamson in an analysis of Philippine manufacturing where the elasticity of substitution was found to be less than one and the technical progress bias against labor.

In the theory of economic development, the essential distinction is between a commercialized agricultural sector using capital produced in the advanced sector and a peasant agricultural sector using only traditional forms of capital.

Inclusion of industrial capital in the agricultural production function is based on the considerable historical evidence of the relatively early application of non farm inputs in agriculture. The extent to which this type of capital is substituted for traditional inputs depends on the relative profitability of each input. The quality and character of land in low-income economy may have an important effect on the pattern of production and on the rate of increse in per capita output.

III. INDUSTRIAL DEVELOPMENT

Assume the population at time t, P(t) is given by

$$P(t) = P_o e^{nt} \qquad 3\text{-}1$$

where, P_o and n are appropriate positive constants and affect the cultural and social background of the country concerned. Further assume that the labor force in the i^{th} sector, $L_i(t)$ depends on the "real wage" in the industrial sector as well as the "real wage" in the non-industrial sector (approximated by the agricultural sector).

Thus, we have

$$L_i(t) = h^i(\omega_1, \omega_2)P(t) \qquad 3\text{-}2$$

h^i is the labor participation in i^{th} sector where h^i and h^2 are positive

$$h^i_j \equiv \frac{\partial h^i}{\partial \omega_j} \gtrless 0 \qquad \begin{matrix} \text{for } i = j \\ \text{for } i = j \end{matrix}$$

$$i, j = 1, 2$$

in the above equation ω_i denotes the "real wage" in the sense that ω_i is the wage rental ratio in the i^{th} sector, $\omega = \frac{W_i}{r_i}$.

The behavioral assumption made on the sign of partial derivative h^i_j is quite general and seems to be in accordance with the historical observation.

From the equation (3-1) and (3-2) we have

$$\frac{\dot{L}_i}{L_i} = \frac{1}{h^i}\left(h^{'}_1, \omega^{'}_1 \dot{k}_1 + h^{'}_2 \omega^{'}_2 \dot{k}_2\right) + n \qquad 3\text{-}3$$

which states that the relative change in the labor force in the i^{th} sector differs from the natural growth rate of population by the relative change in the mobility of labor. In fact, we assume that the real wage in the agricultural sector always remains in the neighborhood of subsistance and is constant as we often observe in the underdeveloped economy, thus, we can see that the relative growth of labor force in the industrial sector is always greater than the natural growth rate of population and the relative growth of labor force in the agricultural sector is always less than the natural growth rate of population, i.e. provided that the capital labor ratio in the sector one increases over time

if ω_2 = constant, we have

$$\frac{\dot{L}_i}{L_i} = \frac{h_1'}{h^i}\ \omega_1'\ \dot{k}_1 + n \qquad 3\text{-}4$$

thus

$$\frac{\dot{L}_1}{L_1} > n \quad \text{and} \quad \frac{\dot{L}_2}{L_2} < n$$

for $\dot{k}_1 > 0$

where $k_1 = \frac{BK_1}{AL_1}$

The above result is certainly consistent with the well-known Japanese and Indian development experiences.

During the period of 1888 to 1930, in which the major part of industrialization took place in Japan, we observe that the basic assumption in the above model holds with good approximation and the relative growth of industrial labor force outstrips the rate of natural growth rate of population and indeed the effective capital-labor ratio of the industrial sector increased over time. This was chiefly accomplished in the form of capital saving innovation. In other words, Japan did make maximum use of the abundant factor, the labor to augment scarce factor capital by adopting labor-using, not labor-saving innovations. In the case of India over the period 1949 to 1960, the growth rate of population was higher than the growth rate of labor in industrial sector with the exception in the period of 1955-1958. The growth rate of capital is higher than the growth rate of labor. It seems that India involved in very labor saving innovations from the beginning of development effort.

The relationship between capital accumulation and the growth rate of labor in industrial sector can be explained as follows,

$$k_1 = \frac{BK_1}{AL_1}$$

$$\dot{k}_1 = \left(\frac{\dot{B}}{A} - \frac{B}{A^2}\right) \frac{K_1}{L_1} + \frac{B}{A} \left(\frac{\dot{K}_1}{L_1} - \frac{K_1}{L_1^2}\right)$$

$$\dot{k}_1 = \frac{B}{A}\frac{k}{L}\left[(b-a) + \left(\frac{\dot{K}_1}{K_1} - \frac{\dot{L}_1}{L_1}\right)\right] \qquad 3\text{-}5$$

From diagram 1 we can see that in Japan $\frac{\dot{K}_1}{K_1} - \frac{\dot{L}_1}{L_1} < 0$

and $\frac{\dot{L}_1}{L_1} > n$ is hold for $\dot{k}_1 > 0$

Thus, $\dot{k}_1 > 0$ if $b > a$

From equation (2-31) for industrial sector $D_1(t) < 0$

We can say, that the industrial sector in Japan is labor using innovation.

In the case of India,

$$\frac{\dot{K}}{K} > \frac{\dot{L}}{L}$$

or $\left(\frac{\dot{K}}{K} - \frac{\dot{L}}{L}\right)$ is positive

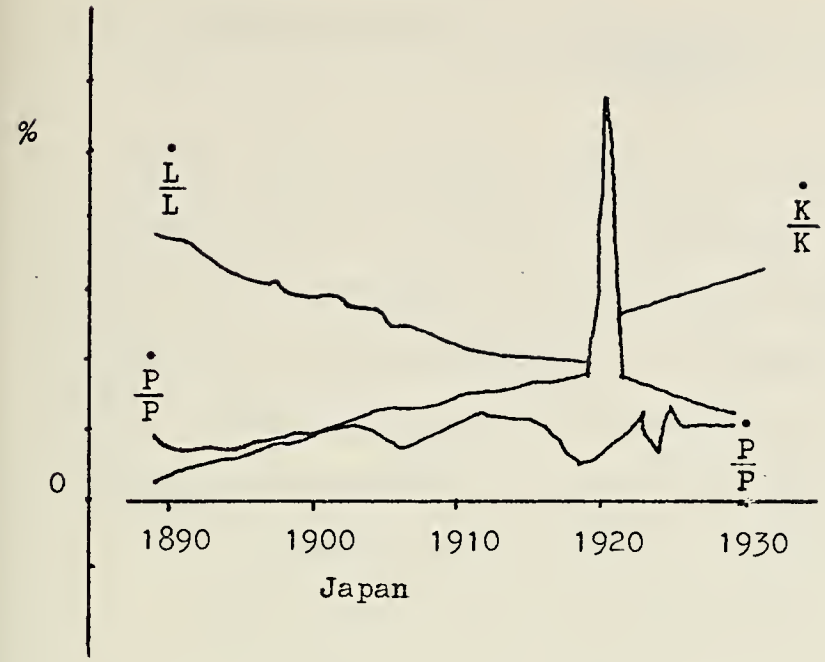
and $\frac{\dot{L}}{L} < n$

from equation (3-4) we get $\dot{k}_1 < 0$

thus $(b-a) < 0$

$a > b$

In industrial sector will be labor saving ($D_1 > 0$).



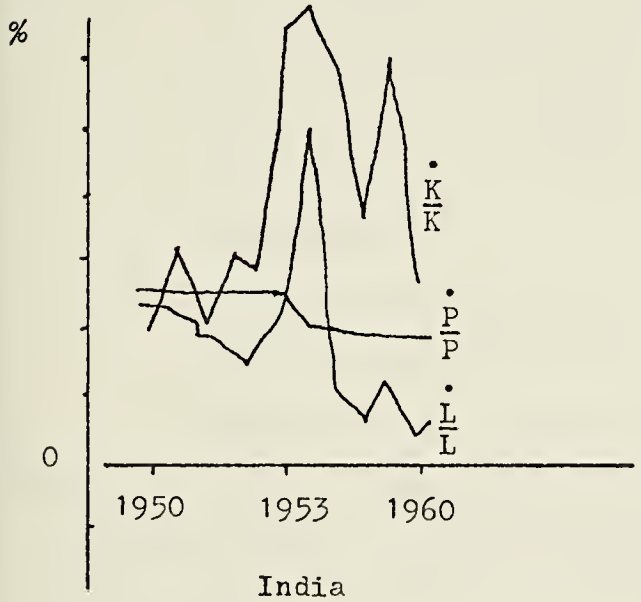


Diagram 1

Source: John C.H. Fei and Gustav Ranis, "Development of Labor Surplus Economy," Richard D. Irwin, Inc., 1964, pp. 125-135.

IV. INTERRELATIONSHIPS BETWEEN AGRICULTURAL AND INDUSTRIAL SECTOR

In a closed economy, where one of the most important pre-conditions of industrial expansion is the achievement of a rate of increase in agriculture productivity that exceeds the concurrent rate of increase in the demand for food. Rising agricultural productivity supports and sustains industrial development in several ways:[11]

1. It permits agriculture to release part of its labor force for industrial employment while meeting the increasing food needs of the non-agricultural sector.
2. It raises agricultural incomes, thereby creating the rural purchasing power needed to buy the new industrial goods and rural savings which may then be mobilized, by direct or indirect means, to finance industrial development.
3. It enables agriculture to supply the major wage-good of industrial workers at prices favorable to the profitability of new industry.

Thus, increasing agricultural productivity makes important contributions to general economic development and that, within considerable limits at least, is one of the pre-conditions which must be established before a take-off into self-sustained economic growth becomes possible.

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[11]Cf. W. Arthur Lewis, Theory of Economic Growth, London, Geo, Allen & Unwin, 1955, pp. 334.

As an economy undergoes industrial development, it a accelerates the rate of agricultural progress in many important ways:[12]

1. Industrialization increases the demand for wage-goods, of which food is initially most important.
2. It stimulates the development of agricultural processing industries, and the integration of the rural and urban economies.
3. It makes available to agricultural workers a wider range of consumption goods, raising their level of wants and encouraging greater productive effort.
4. Industrialization diverts redundant labor from agriculture, to the benefit of both those who leave and those remaining in agriculture.

For an open economy, with access to international trade, the contribution of a generally rising agricultural productivity to industrial development may be diminished. For this kind of economy, it is more economical to import some of its food needs because its comparative advantage lies in non-food production, some of which it may export in exchange for food. However rising productivity in food sector is desirable, both because it may save scarce foreign exchange needed for financing import of industrial capital and because it contributes to the integration of the plantation-peasant agricultural economy, the existence of which has so often restricted the rate and spread of economic progress.

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[12]William H. Nicholls, Agriculture in Economic Development, Mc. Graw-Hill, Book Co., 1964, pp. 13-16.

Industrial development also creates an intellectual environment which is more favorable to the creation of an entrepreneural class, to the expansion of new skills, to capital formation and technical innovation, and to declining birth rates. Auch an environment contributes to increasing productivity not only in the non-agricultural sector but, both directly or indirectly, in the agricultural sector as well. Furthermore, in a country with a poor agricultural resource base, industrialization may represent a superior alternative to domestic agricultural self-sufficiency, with food imports being paid for by industrial exports. On the other hand, for a country which is relatively efficient in the production of certain agricultural products or other primary goods enjoying substantial export markets, domestic industrialization still may contribute significantly to greater stability in its international terms of trade.

Simon Kuznets pointed out three aspects of economic growth that should be measured:[13]

1. The rise in per capita output product.
2. The structure of an economy.

   The significant characteristics of the rises assocated with modern growth are the large and rapid shifts that occur in the structure of an economy.
3. The international aspect.

   The modern economic growth of any one nation is a

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[13]Simon Kuznets, Economic Growth and the Contribution of Agriculture: Notes on Measurement, International Journal of Agrarian Affairs, Vol. 3, pp. 59-75, 1961.

process of shifting from the underdeveloped economy to the developed group, utilizing the appropriate channels of international trade, finances and communications in general.

In low income economy, the significant rise in population, the rise in open unemployment and the redundant labor in agricultural sector will stress the first aspect. Industrialization and mechanization are references to the progress of economic growth as structural aspect. The rise in per capita output product, essential to the aggregative view of economic growth, in and of itself means a shift in consumption and savings patterns and thus contributes to the shift in the industrial and other structures of the economy. The utilization of the technological potential through the development of new industries and new methods of production, which means structural shifts, that permits a rise in product per capita output.

Any sector is part of an interdependent system represented by the country's economy, what a sector does is not fully atributable or credited to it, but is contigent upon what happens in the other sectors, and perhaps also outside the country.

V. FURTHER STUDY TO BE DONE

The other problems of a developing economy that are important for further study are:

1. Economic development with population endogenous.
2. The problem of disguised unemployment in the over populated low income country.

These areas are important for further study in economic growth, especially in low income countries.

VI. SUMMARY AND CONCLUSION

If technical progress is always factor augmenting, the rate of factor augmenting (a and b) can be interpreted as the proportionate rate of increase in effeciency coefficients of the factor inputs, capital and labor.

The rate of technical progress or the intensity of technical progress is a share-weighted average of the proportionate rates of increase in marginal productivities of capital and labor, holding factor inputs constant.

When the rate of factor augmentation of labor is greater than of capital and the output elasticity of capital is greater in industry, then the rate of technical progress in agriculture exceeds that in industry.

The direction of technical change can be measured by $D(t) \gtrless 0$ for labor or capital augmenting.

In low income economies, technological progress in industry has tended to be labor saving, while in agriculture it has tended to be labor using.

In labor surplus economy, if the criterion of success is characterized by the progress in industrialization, then the labor force absorption in this sector can be used as a measure of the progress in development.

High productivity in agricultural sector is the necessary condition for the success of industrialization.

APPENDIX

Derivation of equation (2-24) and (2-25)

$$Y = F(BK(t), AL(t))$$

$$F_1 = \frac{\partial F}{\partial BK} B, \quad F_2 = \frac{\partial F}{\partial AL} A$$

$$\alpha = \frac{F_1 K}{F} = \frac{\left[\frac{\partial F}{\partial BK}\right] BK}{F}$$

$$1 - \alpha = \frac{F_2 L}{F} \qquad \frac{\left[\frac{\partial F}{\partial AL}\right] AL}{F}$$

$$\sigma = \frac{F_1 F_2}{F\ F_{21}} \qquad \frac{\left[\frac{\partial F}{\partial BK}\right]\left[\frac{\partial F}{\partial AL}\right]}{F \dfrac{\partial^2 F}{\partial BK \partial AL}}$$

$$p = \frac{\partial F_1}{\partial t} \frac{}{F_1} = \frac{\partial \left[\frac{\partial F}{\partial BK}\right] B}{\partial t} \frac{1}{F_1}$$

$$= \frac{\left[\frac{\partial F}{\partial BK}\right] \dot{B} + B \left[\frac{\partial^2 F}{\partial BK \partial t}\right]}{B \left[\frac{\partial F}{\partial BK}\right]}$$

$$= b + \frac{\dfrac{\partial^2 F}{\partial BK\ \partial t}}{\dfrac{\partial F}{\partial BK}}$$

$$\frac{\partial F}{\partial t} = \frac{\partial F}{\partial BK} \frac{\partial BK}{\partial t} + \frac{\partial F}{\partial AL} \frac{\partial AL}{\partial t}$$

$$\frac{\partial^2 F}{\partial BK \partial t} = \frac{\partial^2 F}{\partial (BK)^2} \frac{\partial BK}{\partial t} + \frac{\partial^2 F}{\partial BK \partial AL} \frac{\partial AL}{\partial t}$$

p and q defined as proportionate rates of increase in the marginal productivities of capital and labor, respectively, at constant factor inputs.

$$\frac{\partial^2 F}{\partial BK \partial t} = \frac{\partial^2 F}{\partial (BK)^2} \dot{KB} + \frac{\partial^2 F}{\partial BK \partial AL} \dot{LA}$$

$$p = b + \left[\frac{\partial^2 F}{\partial (BK)^2} \dot{KB} + \frac{\partial^2 F}{\partial BK \partial AL} \dot{LA} \right] \frac{1}{\frac{\partial F}{\partial BK}}$$

F is homogeneous of degree one, then $\frac{\partial F}{\partial BK}$ is homogeneous of degree zero in BK and AL:

$$\frac{\partial \frac{\partial^2 F}{\partial (BK)^2}}{} BK = - \frac{\partial^2 F}{\partial BK \partial AL} AL$$

$$p = b + \frac{\partial^2 F}{\partial BK \partial AL} AL \left[a-b \right] \frac{1}{\frac{\partial F}{\partial BK}}$$

Multiplied by,

$$1 = \frac{\frac{\partial F}{\partial AL} F}{\frac{\partial F}{\partial AL} F}$$

$$p = b + \frac{\frac{\partial^2 F}{\partial BK \partial AL} F}{\left(\frac{\partial F}{\partial BK} \right) \frac{\partial F}{\partial AL}} \frac{\frac{\partial F}{\partial AL} AL}{F} (a-b)$$

$$p = b + \frac{1}{q}(1-\sigma)(a-b)$$

$$p = b - \frac{1-\alpha}{\sigma}(b-a)$$

$$q = \frac{\partial\left[\frac{\partial F}{\partial AL}\right]A}{\partial t} \quad \frac{1}{\frac{\partial F}{\partial L}}$$

$$= a + \frac{\frac{\partial^2 F}{\partial AL \partial t}}{\frac{\partial F}{\partial AL}}$$

$$\frac{\partial^2 F}{\partial AL \partial t} = a + \left[\frac{\partial^2 F}{\partial BK \partial AL} \; BK.\, b + \frac{\partial^2 F}{\partial (AL)^2} \; AL.a\right] \quad \frac{1}{\frac{\partial F}{\partial AL}}$$

$$\frac{\partial F}{\partial AL}$$

$$\frac{\partial^2 F}{\partial (AL)^2} \; AL = -\frac{\partial^2 F}{\partial BK \partial AL} \; BK$$

$$q = a + \frac{\partial^2 F}{\partial BK \partial AL} BK(b-a) \quad \frac{1}{\frac{\partial F}{\partial AL}}$$

$$q = a + \frac{\alpha}{\sigma}(b-a)$$

REFERENCES

1. Daniel Hamberg, "Models of Economic Growth," Harper & Row, Publishers, 1971.

2. Edwin Burmeister and A. Rodney Dobell, "Mathematical Theories of Economic Growth," The Macmillan Company 1970.

3. C.E. Ferguson, "The Neoclassical Theory of Production and Distribution," Cambridge University Press, 1969.

4. C.E. Ferguson, "Microeconomic Theory," Richard D. Irwin, Inc., 1972.

5. Allen C. Kelly; Jeffrey G. Williamson; and Russell J. Cheetham," The University of Chicago Press, 1972.

6. John C.H. Fei and Gustav Ranis, "Development of The Labor Surplus Economy," Richard D. Irwin, Inc., 1964.

7. Ansley J. Coale and Edgar M. Hoover, "Population Growth and Economic Development in Low-Income Countries," Princeton University Press, 1958.

8. Joseph J. Spengler, "Population Economics," Duke University Press, 1972.

9. Paul Zarembka, "Toward a Theory of Economic Development," Holden-Day, Inc., 1972.

10. Cf. W. Arthur Lewis, "Theory of Economic Growth," London, Geo, Allen & Unwin, 1955.

11. William H. Nicholls, "Agriculture in Economic Development," Mc.Graw-Hill, Book Co., 1964.

12. H.B. Chenery, "Patterns of Industrial Growth," American Economic Review 50, September 1960, pp. 624-54.

13. R.M. Solow, "Technical Change and the Aggregate Production Function," Review of Economics and Statistics 39, August 1957, pp. 312-20.

14. Ferguson C.E. and Moroney J.R., "The Sources of Change in Labor's Relative Share," Southern Economic Journal 35, April 1969, pp 308-22.

15. Simon Kuznets, "Economic Growth and the Contribution of Agriculture: Notes on Measurement," International Journal of Agrarian Affairs, vol. 3, pp. 59-75, April 1961.

16. Gustav Ranis and John C.H. Fei, "A Theory of Economic Development," American Economic Review, vol. 51, pp. 533-565, September, 1961.

17. Charles Kennedy, "Induced Bias in Innovation and the Theory of Distribution," Economic Journal LXXIV, September, 1964, pp. 541-547.

18. R.M. Solow, "Investment and Technical Progress," Reading in the Modern Theory of Economic Growth, pp. 156-157.

19. R.M. Solow, "A Contribution to the Theory of Economic Growth," Reading in Mathematical Economics, Vol. II, The John Hopkins Press, 1968, pp. 142-171.

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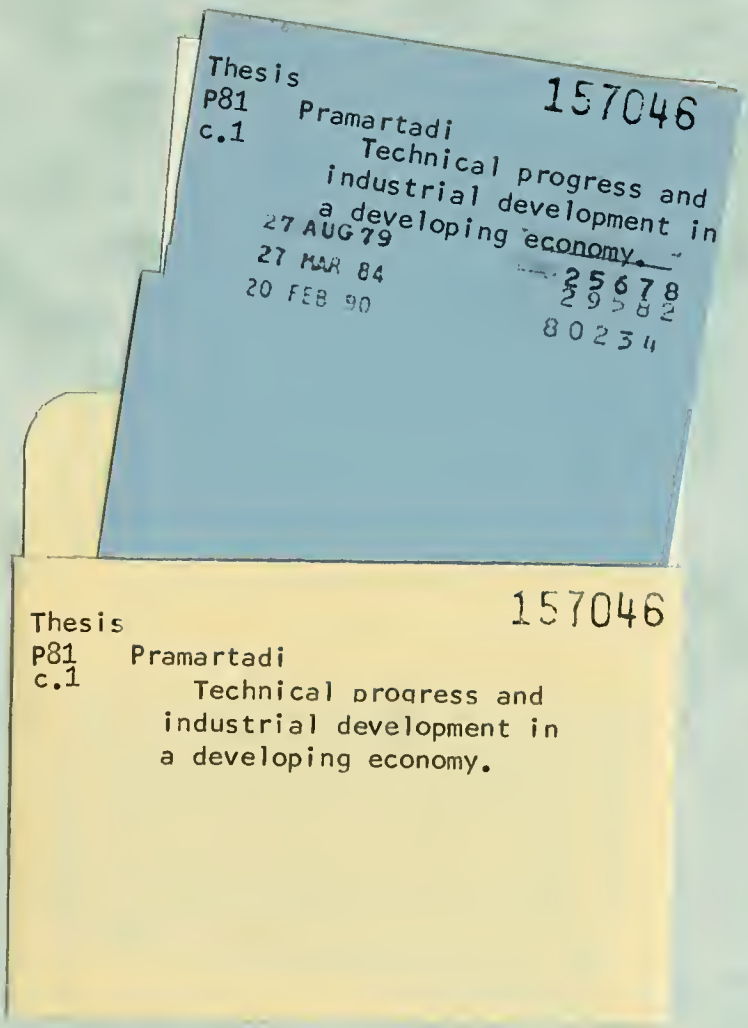

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